

December 12, 1901.

Sir WILLIAM HUGGINS, K.C.B., D.C.L., President, in the Chair.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read :—

- I. "On the Action of the Spurge (*Euphorbia hiberna*, L.) on Salmonoid Fishes." By Dr. H. M. KYLE. Communicated by Professor MCINTOSH, F.R.S.
- II. "Contributions to the Chemistry of Chlorophyll. No. VIII.—Changes undergone by Chlorophyll in passing through the Bodies of Animals." By Dr. E. SCHUNCK, F.R.S.
- III. "On the Constitution of Copper-Tin Alloys." By C. T. HEYCOCK F.R.S., and H. F. NEVILLE, F.R.S.
- IV. "The Effective Temperature of the Sun." By Dr. W. E. WILSON, F.R.S.

The Society adjourned over the Christmas Recess to Thursday, January 23, 1902.

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"Contributions to the Chemistry of Chlorophyll. No. VIII.—Changes undergone by Chlorophyll in passing through the Bodies of Animals." By EDWARD SCHUNCK, F.R.S. Received November 29,—Read December 12, 1901.

Considering the large quantity of food containing chlorophyll consumed by animals feeding on green herbage, it seemed to me it might be of interest to ascertain whether any, and if so what, changes are undergone by the chlorophyll of the food during its passage through the animal body.

It is stated in works on physiological chemistry that the solid excrements of animals contain chlorophyll; but this statement refers apparently to human faeces, and is certainly not correct as regards those of herbivora if unchanged chlorophyll is meant. It would indeed, *a priori*, seem very improbable that chlorophyll, after exposure at a somewhat elevated temperature to acids and other agents, such as it would meet with in its passage through the animal system, would remain unchanged, though, on the other hand, chlorophyll products of decom-

position, some of which, as I have pointed out on former occasions, are very stable bodies, might be looked for in the excrements of animals.

Having treated some of the faeces of a cow that had been fed for some time on grass only, with boiling alcohol, I obtained a dark greenish-brown extract showing an acid reaction, a quantity of undigested matter consisting of stems, woody fibre, &c., being left undissolved. A little of the filtrate, on being mixed with water and shaken up with ether, gave a golden-yellow supernatant liquid, which, if chlorophyll had been present in the material used, would have shown a decided green colour, and would have exhibited the absorption spectrum of chlorophyll. In place of the latter, however, it showed the four absorption bands of phylloxyanthin, as well marked, indeed, as I have ever seen them. This simple experiment proved conclusively the absence of chlorophyll, but in its place the presence of one of its products of decomposition. I have made no attempt to isolate and purify this supposed phylloxyanthin, this being rendered difficult owing to the large admixture of impurities, which are chiefly of a fatty nature. The ethereal liquid just referred to would also have contained the urobilin of the faeces if present, so I imagine at least if I have rightly understood what has been stated regarding that body. The properties of urobilin, however, are not very marked. It is only by its absorption spectrum that it can with certainty be detected, but this spectrum is too inconspicuous and too faint to be easily seen in a solution containing at the same time phylloxyanthin with its dark well-defined bands, which would completely mask those of urobilin situated as these are in the same region of the spectrum. Its presence, too, if proved, would have been of little interest from my point of view, and I therefore made no attempt to establish its presence or absence.

The extract of faeces with boiling alcohol gave, after filtration and cooling, a dark-coloured flocculent deposit, which was filtered off, dried, and treated with boiling chloroform. The filtered chloroformic liquid left on evaporation a quantity of purplish-blue lustrous crystals. These crystals, which are of considerable interest as regards both their properties and their origin, will be described presently. They are more readily prepared by extracting cow-dung after pressure between folds of paper with cold chloroform, filtering, and evaporating the filtrate slowly in a warm place, when the substance separates in the form of brilliant semi-metallic spangles floating in the liquid, which, after collecting and washing with alcohol, have the appearance of a lustrous crystalline mass. From the brilliancy of its appearance an observer might easily be deceived as regards its quantity, which is not really large. I have, however, obtained sufficient to enable me to determine its chief properties, and to justify the conclusion that it is a derivative of chlorophyll closely resembling, though not identical with, phylloxyanin, as I shall presently show.

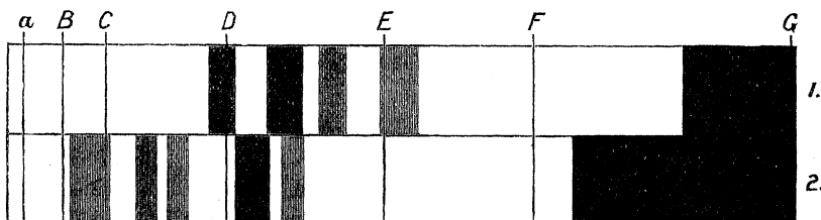
For such as wish to prepare this substance, I may state, as the result of my experience, that it can only be obtained from the faeces of cows or other herbivora that have been fed exclusively on grass or other green vegetable food; those of stall-fed cattle, nourished as they usually are to a great extent with oil-cake, yield none, on account perhaps of the large amount of fatty matter present in that case in the faeces. I may add that the solid excrements of sheep that have been at pasture for some time and living on herbage only, on being treated as above described, yield the same substance, but I have made no experiments with the faeces of other herbivora. I imagine that the yield of this peculiar substance is greatest from material collected in spring or early summer; but this, if correct, may be due to other causes than difference of season.

This substance not having, so far as I can ascertain, been previously observed, I propose to call *Scatocyanin*, a name kindly suggested to me by Professor Wilkins, of Owens College. Its chief properties are as follows:—Under the microscope it appears in the form of thin rhombic plates or elongated flat prismatic crystals, which are pale brown by transmitted light, of a purplish-blue colour with a brilliant metallic lustre by reflected light. When heated between watch-glasses it is decomposed without melting or swelling much or yielding any sublimate; heated further on platinum, it burns away, leaving a little ash. It is almost insoluble in boiling alcohol, ether, carbon disulphide, and benzol, but it dissolves, though not readily, in chloroform, giving a solution which shows an absorption spectrum of five bands, almost identical with those of phyllocyanin. It dissolves in boiling glacial acetic acid, giving a fine crimson solution, which, when sufficiently dilute, shows an absorption spectrum of four bands—of which the two first are well defined, the third faint with some obscuration between it and the second band, the fourth band also faint and not well defined (see fig.). From a saturated solution in boiling acetic acid the substance separates on cooling and standing in lustrous purplish-blue needles.

It dissolves in concentrated sulphuric acid with a brilliant grass-green colour, which, on standing, changes to purplish-blue. The solution now shows a characteristic absorption spectrum of five bands, of which the first and fifth are faint and poorly defined, the second and third well defined, but the fourth only moderately so, while there is much obscuration between the fourth and fifth bands, with just a trace of a sixth band in the green between the fifth band and the total obscuration (see fig.).

The sulphuric-acid solution on being mixed with several times its volume of water changes its colour from purplish-blue to a fine purple without giving any precipitate and without showing any change in its absorption spectrum. On standing, however, for some time the liquid

becomes nearly colourless, and deposits rosettes of lustrous crystalline needles, presumably of unchanged substance; so that it appears no sulphonic acid is formed in this reaction, the colour of the solution in sulphuric acid being due probably to a loose combination of the substance with the acid. The substance is soluble in boiling aniline; the solution is dull red, and gives with alcohol a deposit of brilliant needle-shaped crystals, the filtrate from which shows the same spectrum as the solution in acetic acid. The substance is insoluble in aqueous caustic potash, but dissolves in alcoholic potash, giving a yellow solution.



*Absorption Spectra of Scatocyanin Solutions.*

1. Scatocyanin in glacial acetic acid.
2. The same in concentrated sulphuric acid.\*

There is another substance of definite character and assuming a crystalline form which I have obtained, though not always, along with the preceding. Having treated the faeces of a cow that had lived for some time on green vegetable food, with acidulated alcohol (seventeen parts of rectified spirit to three of sulphuric acid, the mixture prescribed for the preparation of so-called stercobilin), I added water to the filtered extract and shook up with chloroform. The chloroformic liquid after separation was evaporated, when it left a brown syrup. This, treated with boiling alcohol, dissolved in part, a semi-crystalline pink residue being left undissolved, which, after separation, was found to be soluble in boiling acetic acid with a crimson colour, and consisted doubtless of scatocyanin. A further quantity of this was deposited on again evaporating; on further evaporation, the filtrate left a thin brown syrup which was mixed with a large quantity of alcohol. On standing, a voluminous crystalline deposit separated, which was filtered off and slightly washed with alcohol.

The following are the chief properties of the substance so prepared:—When dry it has the appearance of a dull red mass of crystalline needles. Heated on platinum, it melts easily to a brown mass, solidifying again on cooling; on further heating, it gives off red fumes

\* These spectra were mapped by my son, Charles A. Schunck.

and burns away, leaving no ash. When heated in a test-tube or between watch-glasses, it gives a small quantity of amorphous brown sublimate with a few crystalline needles. It dissolves in boiling alcohol, giving a bright yellowish-red solution, which, on cooling, deposits crystalline needles, becoming almost colourless. It is moderately soluble in ether, benzol, and glacial acetic acid; very soluble in chloroform. The chloroformic solution shows no absorption bands, only obscuration in the blue. It is quite insoluble in caustic potash liquor even on boiling. It dissolves in concentrated sulphuric acid, giving a dull red solution, which, after the addition of a considerable quantity of acid, shows no absorption bands, only obscuration in the blue and green; on the addition of water, the solution turns reddish-yellow without giving any precipitate, but on standing for a short time the colour turns to a fine violet, and then shows a broad ill-defined absorption band between the red and green. Not showing any very characteristic reaction but the one last mentioned, it must remain doubtful how and where it originates. It may possibly be a constituent of the green parts of plants not hitherto observed, though I believe it myself to be a derivative of chlorophyll—meaning by chlorophyll the *ensemble* of the colouring matters of green leaves—formed by some unknown process in the animal economy, but the fact of its solutions showing no absorption bands does not lend countenance to this view. Having also observed it on one occasion only, I do not feel justified in giving it a name or in placing it in any known category of vegetable or animal colouring matters.

Another constituent of the faeces remains to be mentioned. It was referred to above as showing in solution the absorption spectrum of phylloxanthin. After all the substances capable of assuming a crystalline form have been separated from the alcoholic extract of the faeces, this phylloxanthin-like substance is found in the final mother liquor. I have not succeeded in obtaining it in a crystalline or any other definite form, on account probably of the large quantity of fatty matter with which it is associated; but there is no reason, I think, to suppose that it differs essentially from the phylloxanthin described in previous communications as a product of the action of acids on chlorophyll.

The conclusions to which the experiments above described lead may be summarised as follows:—

1. The faeces of animals supplied with green vegetable food only—such at least as have so far been examined—contain no chlorophyll, but in its place substances which must be supposed to be derivatives of chlorophyll, formed partly by the action of acids on the chlorophyll of the food, partly by some agency to which the latter is subjected in its passage through the body.

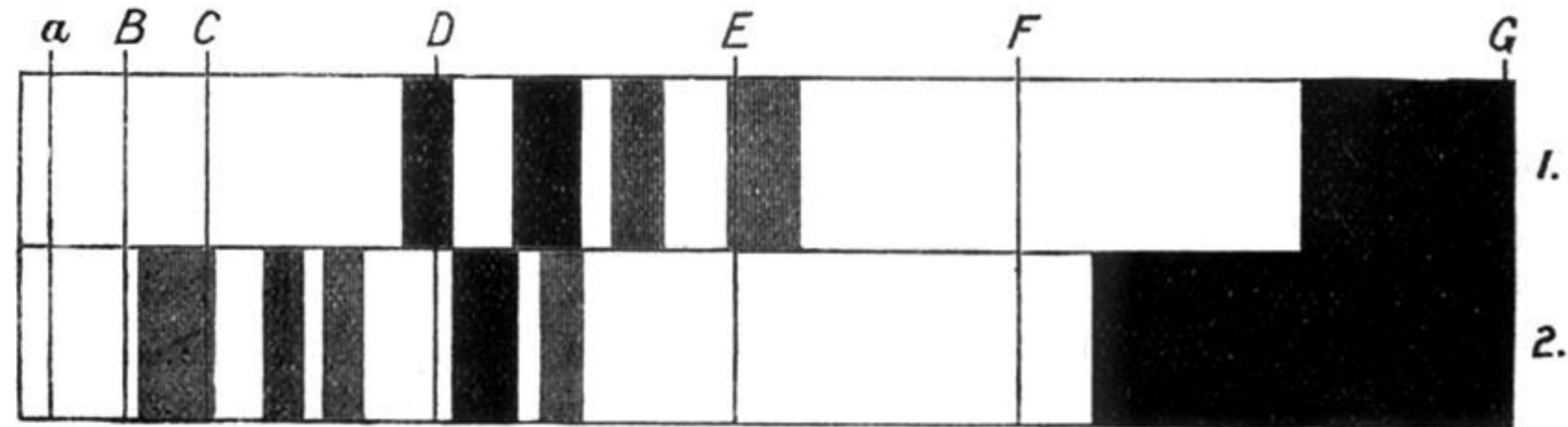
2. Of these substances, one seems to be identical with phylloxanthin,

a well-known product of decomposition of chlorophyll. Another is a substance of well-marked properties, nearly resembling, but not identical with, phyllocyanin. It has not, so far as my experience goes, been hitherto observed as a result of any process of decomposition to which chlorophyll has been subjected outside the animal body. I consider it as a body *sui generis*, characterised by its fine purplish-blue colour and its brilliant metallic lustre. The existence of other products in addition to these two is possible. On one occasion, indeed, a definite crystalline substance was obtained, which seemed to be peculiar, but that it was in any way connected with chlorophyll could not with certainty be maintained.

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“The Effective Temperature of the Sun.” By W. E. WILSON, D.Sc., F.R.S. Received December 5,—Read December 12, 1901.

In March, 1894, Dr. G. Johnstone Stoney communicated to the Society a memoir by myself and Mr. P. L. Gray, entitled “Experimental Investigations on the Effective Temperature of the Sun,” which was published in the ‘Phil. Trans.,’ A, vol. 185 (1894). In these investigations the method we adopted was as follows:—A beam of sunlight was sent horizontally into the laboratory by means of a Stoney single-mirror heliostat. The mirror was an optical plane of unsilvered glass, and the beam was directed into one aperture (A) of a differential Boys’ radio-micrometer. The other aperture (B) received the radiation from a strip of platinum, which could be raised to any desired temperature by an electric current supplied by a battery of accumulators. The temperature of this strip was at any moment determined by its linear expansion, the instrument being previously calibrated by melting on it minute fragments of AgCl and of pure gold, as in Joly’s melsdometer. In front of the aperture (B) of the radio-micrometer was placed a stop with a circular hole of 5.57 mm., and the distance of this hole from the receiving surface of the thermo-couple was 60.2 mm. This gave for the angle subtended by a diameter of the aperture at the receiving surface  $5^{\circ}30'$ . Knowing then (i) the ratio which the angular diameter of this circular aperture bears to that of the sun, (ii) the temperature of the platinum strip at the moment that the radio-micrometer is balanced, (iii) the amount of the sun’s radiation lost by reflection from the heliostat mirror and also by absorption in the earth’s atmosphere, it is possible on any assumption with regard to the law connecting radiation with temperature, to determine the effective temperature of the sun. A series of very accordant observations were made in this way, the mean of which gave  $6200^{\circ}$  C. as the effective solar temperature.



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